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Natural Regeneration in Old-Growth Redwood Cuttings

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ABSTRACT: Redwood natural regeneration proceeds rapidly after harvest cuttings in old-growth stands. On the first clearcutting at the Redwood Experimental Forest, stumps began to sprout before the logging was finished and first seed had germinated by midwinter, 3 months after the cuttings were finished. Seed production was abundant in 5 successive years. Sprouting varies by stump diameter--the smaller and usually younger stumps sprout more often than the larger, older ones.

A harvested old-growth redwood (Sequoia sempervirens (D. Don)Endl.) forest can begin replacing itself in an amazingly short time. This conclusion is borne out by studies at the Redwood Experimental Forest, north of Klamath in Del Norte County, Calif. We began first cuttings in the spring of 1959. By August redwood stumps had started to sprout--even before all logs had been removed. By November fresh seed had fallen[1] on the recently stirred mineral soil During the first week in January newly germinated seedlings were found. Thus 3 months after harvesting was completed on this particular cutting, redwood sprouts were growing well and seedlings had started. A new forest was growing.

Research in natural regeneration of redwood is a part of the silvicultural studies being conducted at the Experimental Forest. We are investigating effective harvesting methods to convert old stands into younger managed forests. The harvesting, or reproduction cutting, methods are: clearcutting in small blocks, shelterwood cutting, and selection cutting.

Clearcuttings range in size from 10 to 20 acres and are alternated with reserve seed blocks of about the same size.

On the shelterwood cuttings, more than half the trees were removed in the first cut to encourage reproduction. On half of each shelterwood, all of the carefully selected seed trees will be cut after the reproduction is satisfactorily established. On the other half, the reserved overstory will be removed in two equal cuts: the first with the above final cut, and the second about 10 years later.

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[1] Boe, Kenneth N. Redwood seed dispersion in old-growth cutovers. U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Res. Note 177. 7 pp., illus. 1961.

Selection cuttings are intended to produce and maintain uneven-aged forests. The first cut removed selected, larger, older trees on about 10 percent of each area. Smaller trees also were cut if they were defective, dying, or occupied space needed to fell the big redwoods. Unevenly spaced throughout the stand, the reserved trees tend to be arranged both singly and in small groups.

Many kinds of plots and sampling devices are being used to study natural regeneration that follows the first harvesting of the old-growth timber. Such techniques include seed traps for determining seed production, small plots located on specific seedbeds to follow seedling establishment, and counting, measuring, and tagging sprouts on sample stumps.

Seed Production

Natural regeneration of the harvested forests hinges on seed production and dispersal. Redwood starts flowering in November, and continues pollination and fertilization during midwinter. Cones and seeds mature during summer. The first sound seed may be trapped as early as September. But the peak period for dispersal extends from November through February when 95 to 98 percent of the seeds fall. This is a favorable period, for winter rains bring the seed in close contact with the soil, allowing seeds to germinate when temperatures are right.

Sound seed must reach all parts of a cutover area for successful regeneration of that area. Where cone bearing trees reserved on cutover areas ranged from 3 to 14 per acre, sound seed production varied accordingly. For 1 year we calculated that these areas had from 1.4 million to 4.4 million sound seeds per acre. Sound seed has both endosperm and embryo; hence it can germinate on suitable seedbed that is favored by adequate moisture and proper temperature. Redwood characteristically has a low percentage of sound seed. Of many samples we have examined the percent of soundness ranged from 0 to 18 percent. Nevertheless, sound seed has high viability. In testing several lots in the laboratory, we found that 68 percent or more germinated.[2]

In 5 consecutive years there was not a single year without abundant seed production at the Redwood Experimental Forest. This characteristic of heavy seed production was also reported by Muelder and Hansen[3] as applying to forests in southern Humboldt, Sonoma, San Mateo, and Santa Cruz counties. They observed much lower seed production in Mendocino County.

On the clearcutting where all trees are harvested, seed is blown in from the marginal forest. How far is this seed carried by the wind?

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[2] *Op. cit.*

[3] Muelder, D. W., and Hansen, J. H. Observations on cone bearing of *Sequoia sempervirens*. Calif. Agr. Exp. Sta. Berkeley, Calif. Forestry and Forest Products 26. 6 pp., illus. 1961.

We need to know the distance to limit size of clearcuttings that are to be naturally reproduced. Seed was caught in seed traps placed 400 feet from the timber edge within the clearcutting. The number of seed amounted to 6 to 10 percent of that produced by the marginal stand. Maximum distance of dispersal was not determined. But by plotting graphically the amount of seed over distance, we concluded that significant amounts of seed would be blown an additional 100 to 200 feet. Person and Hallin[4], who used a different study technique, obtained similar results. They concluded that edges of cutover areas more than 400 feet downhill and 200 feet uphill did not provide for satisfactory reproduction. Furthermore, they found low levels of reproduction stocking at 800 feet downhill and at 400 feet uphill. Fritz[5] concluded that redwood seed will disperse in adequate amounts a distance equal to that of the tree heights.

Germination and Survival

Germination is generally abundant on most seedbeds where moisture and temperature are favorable. On cutover areas two types of seedbeds predominate: (a) mineral soil of various kinds resulting from stirring the soil by skidding and layout-skidroad construction; and (b) burned seedbed resulting from slash burning. Burned seedbeds vary from a cindery surface as the result of a hot, sustained slash fire to a condition similar to mineral soil resulting from a light burn. Seedbeds in a cindery condition perform poorly, but other types of burned seedbeds and mineral soil are favorable to redwood germination and survival.

At the end of the first year and depending on amount of sound seed available, seedlings may number in the thousands per acre. Mortality of the tiny seedlings, which are only 1 to 2 inches tall, runs very high. But additional germination occurs in succeeding years--at least through the third year--so mortality and replacement are constantly in progress. By the end of the third growing season on mineral seedbeds, the number of surviving seedlings per acre from seed that had germinated the first year was as follows:

	Surviving seedlings per acre
Cuttings:	
Selection	219,000
Shelterwood	107,000
Clearcutting:	
Average	85,000
Center	36,000

On burned seedbeds the same pattern prevailed but at a somewhat lower rate per acre. The lower survival on heavily burned cindery seedbeds accounted for the fewer seedlings.

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[4]Person, Hubert L., and Hallin, William. Natural restocking of redwood cutover lands. J. Forestry 40: 683-688. 1942.

[5]Fritz, Emanuel. Some principles governing the growing of redwood crops. J. Forestry 49: 263-266. 1951.

The ratio between number of growing redwood seedlings to the number of sound seed varies. On mineral soil results from one series of cuttings were:

Selection cutting	5 percent
Shelterwood cutting	8 percent
Clearcutting:	
Average	9 percent
Center	18 percent

We might conclude that clearcuttings are more favorable for establishment of redwood than partial cuttings, but this conclusion is premature. One reason is that we need to evaluate seedling establishment more closely on microsites--the small environments that directly affect a few seedlings. Second, we need to study a repetition of these natural regeneration events on other cuttings to determine if this was an unusual or the usual pattern.

Stump Sprouts

Redwood has the unique characteristic for a conifer that it sprouts, and most if not all sprouts originate from dormant buds. Sprouts from stumps grow into normal trees. So in addition to seedling growth, we may expect new trees from sprouts. Sprout growth starts very quickly after cutting, varying somewhat by season. We have had good examples in which sprout growth began in August and again in early spring.

Stumps of smaller (usually younger) redwoods sprout more often than do larger (usually older) stumps. In one cutting experiment we found that 62 percent of all redwood sample stumps sprouted; 79 percent of the smaller stumps, those under 56 inches in diameter, sprouted; but only 44 percent of those 116 inches in diameter sprouted.

Injury to redwood bark produces different effects that are now only superficially understood. Light burning and heaping of soil against parts of stumps seems to stimulate sprouting frequency. But heavy burning and debarking seem to limit the sprouting. Furthermore damage of any kind results in lower initial height growth.

The stump sprouts will contribute a significant proportion of the trees in the new stand. But because old-growth stumps are widely spaced, seedlings are essential to produce a full stand of trees. We have not yet determined the proportional stocking by each kind of reproduction at the Redwood Experimental Forest. By present appearances both classes of trees are well represented and growing vigorously. Many 5-year old sprouts are already 15-feet tall. Seedlings start slower, as illustrated by their present heights of 1 to 4 feet at age 5. But eventually they will grow as fast as sprout trees.

Conclusion

A critical look at the Redwood Experimental Forest trial cuttings will convince both the layman and the forester that redwood young-growth is abundant there. Our records verify a quick start of a new forest. The struggle for survival, particularly of the tiny seedlings, can also be seen, but only by a careful observer. The probable outcome can be seen, too. The sturdier tree seedlings are now overtopping the weaker ones and other vegetation. Sprouts, too, show this developmental struggle. The stronger dominant sprouts amount to only a few of many on each sprouting stump. But they are gaining on their rivals. Already stump sprouts overtop most shrub growth.

The developmental sequence reported here is based on 5 years' observations of one series of experimental cuttings. A trained observer may discover differences from these results when he compares them with those from other harvested stands and other time periods. This is expected; it is nature's variation expressed in the processes of germination, survival, development, competition, and growth. But there is convincing evidence that the characteristics of natural regeneration for old-growth redwood on the Experimental Forest also apply to this species throughout the northern part of its range.

The Author

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